

Energy Physics") not included in Part 16 which has the same title?

Finally, the selection of excerpts and papers is very spotty, particularly in the pre-twentieth-century parts. For example, any anthology of the history of atomism is incomplete without a selection from or even a mention of Pierre Gassendi. Similarly, the contributions of the Germans to kinetic theory are slighted. We have Waterston, but not Clausius! Indeed, we have no selections at all from the champion of nineteenth-century atomism, Ludwig Boltzmann. The book suffers badly from these omissions.

It should be mentioned that the volumes contain a number of interesting new translations. The fascinating paper by Walter Kaufmann, for example, on the apparent mass of the electron is translated for what I believe is the first time.

In sum, the book is suitable neither for scholars, students, nor the lay reader who wishes insight into the history of science. It may prove valuable as an entrée for nonscientists into the maze of modern physics, or a handsome display piece in the front-room bookcase.

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**L. Pearce Williams.** *The Origins of Field Theory*. (Studies in the History of Science.) x + 148 pp., bibl., index. New York: Random House, 1966. \$1.95 (paper).

There are few monographs in the history of nineteenth-century physics which one can confidently place in the hands of students, so it is a pleasure to report that this first volume in a series of studies in the history of science adds very usefully to their number. Professor Pearce Williams describes his book as an outgrowth of his own recent biography of Michael Faraday. In fact it complements that definitive work by placing Faraday's ideas in the context of the development of field theory from

Newton to Maxwell. There is an interesting chapter on the little-understood influence of *Naturphilosophie* upon physical theory, followed by two chapters on Faraday and an all-too-brief chapter on Maxwell's electrodynamics.

The author charms and disarms the critic at the outset by warning his reader that some of his interpretations are highly controversial among scholars, particularly in regard to the German Nature Philosophy and to the relative importance of Faraday and Maxwell. It is indeed in the first of these areas that I have my own major reservations about his account. He traces the origins of field theory in the eighteenth century to a conscious revolt against Newtonianism, which he finds exemplified in the work of Kant, Schelling, and Oersted. Newtonianism itself he characterizes as a rather simpleminded Democritan atomism, dependent on a preexisting absolute space, and implying a view of causation as mere contingent succession of events in an independent absolute time. This view, he holds, was antipathetic to the concept of interrelation of physical forces throughout space which was necessary for the emergence of field theory. Kant is described as the foremost destructive critic of this Newtonianism, whose philosophical analysis rendered atomism untenable, and thus prepared the way for Oersted, Davy, and Faraday to introduce the continuous force field, and to "free men's minds from the thralldom of a century of Newtonian orthodoxy" (pp. 50-51).

But it is difficult to recognize eighteenth-century physics in this caricature of Newtonianism. Newton himself may have been ambiguous in his attitude to forces and atoms, but certainly he was not a Democritan atomist, he admitted distance forces as *verae causae*, and was at least doubtful whether space empty of ponderable matter was in the strict sense void of substance. The eighteenth-century Newtonians exploited these ambiguities to the full. It is impossible to recognize the physics of distance forces, of heat atmospheres, and of almost Cartesian imponderable fluids in Williams' "thralldom of . . . New-

tonian orthodoxy." It would be difficult too, to find any great influence in physics of Hume's reduction of causation to mere time sequence.

Again, Williams' view of Kant is oversimple. Kant's avowed intention was, after all, to provide epistemological underpinning for Newtonian science as the necessary condition of our experience of the world! He may of course have been mistaken in his own estimate of what he accomplished, but it is hard to see his continuum of forces in the *Metaphysical Foundations* as anything but a natural extension of Boscovichean attractive and repulsive forces, and these are central to the Newtonian tradition itself. (Williams banishes Boscovich to the following chapter, as a precursor of field theory. Boscovich certainly does not fit Williams' picture of eighteenth-century Newtonianism, but surely he was far more typical of his period than this picture allows.) Moreover it is not quite correct to describe Kant as a champion of the infinite divisibility of matter as opposed to atomism. In the second Antinomy of the first *Critique* Kant argues that *both* these theories of matter are incoherent, and concludes that nothing can be known of the structure of matter in itself. That he prefers a continuum of forces to atoms as a regulative principle owes more to the existing Newtonian force theory than to any epistemological critique of it.

The breakthrough to field theory should be seen rather in the replacement of central distance forces by continuous distributions of force in space. It was this point which made Oersted's discovery at once so difficult and so unexpected, for the magnetic needle moved *out of* the plane of the forces instead of toward their centers, and it was also this which Faraday explicitly argued in terms of his curved force lines, and which was the experimental core of the dispute between Faraday and Maxwell on the one hand, and the mathematical successors of Ampère on the other. The significance of these mathematical developments, and the interaction of mathematical and physical analogies, deserves more detailed study

than it receives in the last chapter of the book, where even the crucial notion of displacement current is hardly mentioned. I cannot close, however, without a word of gratitude for a hitherto unpublished sidelight: a charming letter from the twenty-seven-year-old Maxwell to Faraday, gently and respectfully explaining how Faraday has misunderstood gravitational force, which is after all just another example of Faraday's own "mode of looking at Nature."

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**Helen Wright.** *Explorer of the Universe: A Biography of George Ellery Hale.* 480 pp., pls., index, notes. New York: Dutton, 1966. \$10.00.

A good technical institute should develop men capable of conceiving great projects, and whose ambitions cannot be completely satisfied by the work of executing them. This thought, expressed by George Ellery Hale, well captures the image of Hale himself as drawn by Miss Wright in *Explorer of the Universe*. This biography chronicles Hale's extensive contributions, both innovative and organizational, to the many areas of science and general culture with which he was involved.

This book is directed as much to the interested public as to historians of science. It follows closely and dramatically Hale's political maneuverings and gambings which were a necessary part of his zealous crusade to convince wealthy men and incipient foundations to support scientific and humanistic researches. It tells, for instance, the background of the Henry E. Huntington Library—of Hale's competition with the rare book dealer Rosenbach and the art dealer Duveen for control of Huntington's money.

For the reader unfamiliar with astronomical problems the author has carefully explained the more elementary scientific concepts and glossed over the more complicated ones. Hale's astro-